Updated Evidence-Based Systematic Review: Effects of Intensity of Treatment and Constraint-Induced Language Therapy for Individuals With Stroke-Induced Aphasia

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Background
This is an updated version of the original evidence-based systematic review (EBSR) published in 2008 in the *Journal of Speech, Language, and Hearing Research* (see http://jslhr.asha.org/cgi/content/full/51/5/1282).

The use of constraint-induced language treatment (CILT) by speech-language pathologists continues to gain momentum as a viable treatment for individuals with stroke-induced aphasia. Since our original systematic review of the literature (Cherney, Patterson, Raymer, Frymark, & Schooling, 2008), additional research has emerged investigating the key principles of CILT—*forced use of verbal language* and *high-intensity massed practice* (Pulvermüller et al., 2001).

Objective
To evaluate the effects of intensity and CILT on individuals with stroke-induced aphasia. See Appendix A1 for the original clinical questions.

Search strategy
An updated search of 24 electronic databases such as MEDLINE (January 2006 to August 2010), PsycINFO (January 2006 to August 2010), *The Cochrane Library* (February issue, 2010), and CINAHL (January 2006 to August 2010) was conducted using key words related to stroke-induced aphasia, amount and intensity of treatment, and CILT. The titles and abstracts of all articles were independently assessed by two reviewers and the full texts of relevant articles were obtained for further scrutiny. References of all full-text articles were scanned to identify additional literature of relevance. See Appendix A2 for search methodology.

Selection criteria
Inclusion required meeting the following criteria: (a) English-only studies published in peer-reviewed journals with original data addressing one or more of the original clinical questions, (b) active treatment examining CILT or directly comparing two different intensities of an aphasia treatment, and (c) included participants ages 18 years of age or older with stroke-induced acute or chronic aphasia. Exclusion criteria consisted of studies pertaining to individuals with cognitive deficits as well as mixed treatments or populations in which data could not be analyzed separately. Studies that used pharmacological intervention for aphasia treatment were also excluded. See Appendix A3 for the list of excluded studies and reasons for exclusion.

Data collection and analysis
Two reviewers independently applied the inclusion criteria, assessed study quality and extracted data from included studies using ASHA's levels of evidence scheme outlined in the previous version of this review (Cherney et al., 2008).

Main results
In the original 2008 review, we identified 10 studies relevant to the treatment of stroke-induced aphasia, with five studies investigating treatment intensity (see http://jslhr.asha.org/cgi/content/full/51/5/1282/T7), four studies examining CILT (see http://jslhr.asha.org/cgi/content/full/51/5/1282/T8), and one examining both. This updated review identified 16 new studies—13 pertaining to CILT and three related to intensity of aphasia treatment.

Table 1 displays the clinical questions addressed, stage of research, and methodological quality of the included studies. Of these, only three (Bakheit et al., 2007; Goral & Kempler, 2009; Meinzer, Streiftau, & Rockstroh, 2007) were considered efficacy research. The remaining 13 were classified as exploratory research. Similar to the original review, the majority of studies described participants and treatments sufficiently to allow for study replication. All but two (Breier, Maher, Schmadeke, Hasan, & Papanicolaou, 2007; Harnish, Neils-Strunjas, Lamy, & Eliassen, 2008) provided probability data and 13 of 16 (81%) allowed for calculation of treatment effects for one or more reported outcomes.

Table 2 provides a detailed description of the 202 participants studied, including type, severity, and chronicity of aphasia. Of the participants included, half (50.5%; 102/202) exhibited chronic aphasia with time post onset (TPO) ranging from 6 months to 12 years and half (49.5%; 100/202) exhibited acute aphasia with TPO ≤ 3 months (Bakheit et al., 2007, treatment intensity; Kirmess & Maher, 2010, CILT). Thirteen studies reported aphasia classification type (fluent vs. nonfluent) or type of aphasia (e.g., Broca's, Wernicke's, conduction). The majority of studies included participants with nonfluent aphasia ranging from moderate to severe.

CILT results: Table 3 outlines the treatment variables and major findings of the 13 studies examining CILT. One hundred of the 202 total participants received CILT, with 4% (4/100) at the acute phase of recovery and 96% (96/100) at the chronic phase of recovery. All 13 studies contributed data to examine the effects of CILT on measures of language impairment. Six also examined the effects of CILT on measures of communication activity/participation (Breier, Maher, Novak, & Papanicolaou, 2006; Brier et al., 2007, 2009; Faroqi-Shah & Virion, 2009; Goral & Kempler, 2009; Kirmess & Maher, 2010) and four (Breier et al., 2007; Faroqi-Shah & Virion, 2009; Goral & Kempler, 2009; Kirmess & Maher, 2010) addressed the maintenance effects of treatment after CILT. Interestingly, the exploratory studies revealed mixed results in support of CILT, while the two efficacy studies (Goral & Kempler, 2009; Meinzer, Streiftau, & Rockstroh, 2007) reported statistically significant changes favoring CILT on various measures of language impairment and communication activity/participation. It is important to note that several included CILT studies have modified the technique from the original description of Pulvermüller et al. (2001), but the key principles of constraint, massed practice, and shaping were retained.

Intensity results: Table 4 illustrates the treatment variables and major findings of the 102 participants from three studies investigating the effect of treatment intensity on measures of language impairment, the majority of which (95%; 97 of 102) came from the Bakheit et al. (2007) trial. This study compared standard care (2 hr per week) to intensive treatment (5 hr per week) for individuals receiving speech and language intervention at the acute stage of recovery. No significant difference was found between more intensive (M = 35.6 hr) and less intensive (M = 19.3 hr) treatment on the Western Aphasia Battery Aphasia Quotient (Kertesz, 1982). The remaining two studies addressed language impairment outcomes at the chronic stage of recovery. Of these studies, only one (Ramsberger & Marie, 2007) provided statistical data to compare a nonintensive (2 times per week) to an intensive (5 times per week) computer naming treatment. The authors reported mixed findings, with two of the four participants favoring more intensive treatment and two favoring less intensive treatment. Although all four participants demonstrated maintenance of treatment gains, only one (Participant 3) was considered significant. These

findings differ from the original review in which the majority of studies found increased treatment intensity to be associated with positive changes in outcome measures of language impairment.

Authors' conclusions

While the update of this review uncovered additional literature supporting the benefits of CILT for individuals with stroke-induced aphasia, the conclusion and clinical message remains unchanged. The majority of the evidence supporting the use of CILT is exploratory in nature. Future research beyond the exploratory phase of study is warranted to determine the efficacy of CILT. Given the findings from Bakheit et al. (2007), further review of studies that provide high intensity massed practice, an important component of CILT, should be considered.

Finally, although not specific to our clinical questions, it is important to note that a number of studies included in this review provided neurophysiologic data examining the neurocorrelates of behavioral changes. Investigation focusing on changes in neural activation patterns will further contribute to our understanding of CILT.

At this time, although research findings suggest the positive effects of CILT, clinicians should interpret the findings of this review judiciously, and as always, in conjunction with clinical expertise and the patient's preferences to determine the most appropriate treatment plan.

Acknowledgements

This work was supported by the American Speech-Language-Hearing Association's National Center for Evidence-Based Practice in Communication Disorders.

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Table 1. Methodological quality of included studies, stage of research, and clinical question(s) addressed.

			Quality indicators							
Citation	**Question(s) research phase**	**Study design**	**Protocol description**	**Group/subject comparability**	**Assessor blinding**	**Sampling allocation**	**Treatment fidelity**	**Significance**	**Precision**	**ITT**
Bakheit et al., 2007 (Intensity)	Q 3 Efficacy	Trial	+	+	+	Random; adequate description	–	+	+	+
Breier et al., 2006 (CILT)	Q 6,7 Exploratory	Case series	+	+	–	Convenience	+	+	+	N/A
Breier et al., 2007 (CILT)	Q 6,7,10 Exploratory	Case study	+	+	–	Convenience	–	–	–	N/A
Breier et al., 2009 (CILT)	Q 6,7 Exploratory	Case series	+	+	–	Convenience	–	+	+	N/A
Faroqi-Shah & Virion, 2009 (CILT)	Q 6,7,10 Exploratory	Case series	+	+/–	+	Convenience	–	+	+	N/A
Goral & Kempler, 2009 (CILT)	Q 6,7,10 Efficacy	Single subject	+	+	+	Convenience	–	+	+	N/A
Harnish et al., 2008 (Intensity)	Q 1 Exploratory	Case study	+	+	–	Convenience	–	–	–	N/A
Kirmess & Maher, 2010 (CILT)	Q 8,9,10 Exploratory	Case series	+	+	–	Convenience	+	+	+	N/A
Meinzer et al., 2006 (CILT)	Q 6 Exploratory	Case study	+	+	–	Convenience	–	+	–	N/A
Meinzer et al., 2007 (CILT)	Q 6 Exploratory	Case study	+	+	–	Convenience	–	+	–	N/A
Meinzer et al., 2008 (CILT)	Q 6 Exploratory	Case series	+	+	–	Convenience	–	+	+	N/A
Meinzer et al., 2009 (CILT)	Q 6 Exploratory	Case series	+	+	–	Convenience	–	+	+	N/A
Meinzer, Streiftau, & Rockstroh, 2007	Q 6 Efficacy	Trial	+	+	+	Random; inadequate description	–	+	+	+

(CILT)										
Ramsberger & Marie, 2007 (Intensity)	Q 1,5 Exploratory	Single subject	+	+	–	Random; inadequate description	+	+	+	N/A
Richter, Miltner, & Straube, 2008 (CILT)	Q 6 Exploratory	Case series	+	+	–	Convenience	–	+	+	N/A
Szaflarski et al., 2008 (CILT)	Q 6,7 Exploratory	Case series	+	+	–	Convenience	–	+	+	N/A

Note. ITT = intention to treat analysis; N/A = not applicable; Q = question.

Table 2. Participant characteristics.

Study	*N*	Age (years)	Education (years)	Gender M;F	RH	TPO (years)	Etiology	Aphasia type	Aphasia severity	Aphasia test score
Bakheit et al., 2007 (Intensity)	97	*Intensive*: 71.2 (14.9) *Standard*: 69.7 (15.0)	10.9 (2.9) 10.5 (2.1)	26;25 21;25	90% 93%	34.2 days (19.1) 28.1 days (14.9)	85 TE 12 H	—	—	*I* WAB AQ *M* = 44.2 (30.2) *SC* WAB AQ *M* = 37.9 (27.2)
Breier et al., 2006 (CILT)	6	62.0 (9.7)	13.5 (1.9)	4;2	100%	3.9 (1.7)	6 I	5 Broca's 1 conduction	Mod–severe	WAB AQ *M* = 52.2 (22.0)
Breier et al., 2007 (CILT)	1	62.0	16	F	100%	1.1	H	—	Mod–severe	WAB AQ = 43.0
Breier et al., 2009 (CILT)	23	54.0 (11.0)	12+ (0.08)	16;7	100%	≥1	2 H 21 I	—	Mod–severe	WAB AQ *M* = 57.0 (17.0) BNT *M* =19.0 (17.0)
Faroqi-Shah & Virion, 2009 (CILT)	4	57.8 (9.8)	16.8 (3.0)	3;1	100%	5.1 (4.5)		3 Broca's 1 agrammatic	—	WAB AQ *M* = 75.5 (13.2) BNT *M* = 45.8 (12.4) OAN *M* = 38.8 (5.1)
Goral & Kempler, 2009 (CILT)	1	60.0	—	M	—	12	—	Nonfluent	—	CLQT CS = 3.4 BDAE-3 Aud. Comp. = 12%ile BDAE-3 Cookie Theft = 13%ile BDAE-3 Repetition = 55%ile BDAE-3 Naming = 37%ile BDAE-3 Reading = 26%ile BDAE-3 Writing = 18%ile
Harnish et al., 2008 (Intensity)	1	52.0	—	F	—	8	—	Conduction	—	WAB AQ = 76.1
Kirmess &	3	66.7 (23.0)	>12	2;1	100%	46.8 days (9.86)	1 H	Nonfluent	2 severe 1 NR	NGA overall = 110.3

Maher, 2010 (CILT)							2 NR			
Meinzer et al., 2006 (CILT)	1	80.0	—	F	100%	2.1	I	Wernicke's	—	AAT PS = 47.5
Meinzer et al., 2007 (CILT)	1	35.0	18+	M	100%	2.7	I	Amnestic	Mod	—
Meinzer et al., 2008 (CILT)	11	49.1 (13.4)	—	7;4	100%	6.0 (11.3)	2 H 9 I	7 Broca's 1 global 2 Wernicke's 1 not classified	4 mild 6 mod 1 severe	AAT PS *M* = 51.8 (4.5)
Meinzer et al., 2009 (CILT)	10	45.1 (17.5)	10.7 (1.8)	4;6	100%	0.6 (1.5)	2 H 8 I	1 amnestic 4 Broca's 2 global 1 Wernicke's 1 not classified	3 mild 7 mod	AAT PS *M* = 50.1 (5.5)
Meinzer, Streiftau, & Rockstroh, 2007 (CILT)	20	*CILT-SLP*: 50.2 (10.1) *CILT-R*: 62 (8.9)	11 (1.6)	16;4	100%	2.6 (1.6) 3.9 (1.4)	2 H 18 I	2 amnestic 11 Broca's 3 global 3 Wernicke's 1 not classified	8 mild 9 mod 3 severe	*SLP* AAT PS *M* = 50.6 (4.8) *R* AAT PS *M* = 52.7 (4.0)
Ramsberger & Marie, 2007 (Intensity)	4	67.5 (5.4)	12+	1;3	—	2.6 (2.4)	—	1 anomic 1 Broca's 1 Wernicke's 1 conduction	—	*P1* WAB AQ = 69 *P2* WAB AQ = 53 *P3* ADP SS = 90 *P4* ADP SS = 107
Richter, Miltner, & Straube, 2008 (CILT)	16	58.3 (9.6)	—	12;4	100%	≥1	—	7 anomic 7 Broca's 2 global	—	AAT SS *M* = 3.3 (0.91) AAT TT *M* = 33.8 (16.7)
Szaflarski et al., 2008 (CILT)	3	58–64	14.6	3;0	100%	≥2	3 I	1 fluent 2 nonfluent	Mod–severe	BDAE-3 Aud. Comp. = 28.9 BDAE-3 Verbal Exp *M* = 25

Note. Dashes indicate data not reported by study author. ADP SS = Aphasia Diagnostic Profile standard score; AAT PS = Aachen Aphasia Test; Aud. Comp. = auditory comprehension; BDAE = Boston Diagnostic Aphasia Examination; BNT = Boston Naming Test; CILT = constraint induced language treatment; CILT-R = constraint induced language treatment–relative; CILT-SLP = constraint induced language treatment–speech-language pathologist; CLQT CS= Cognitive Linguistic Quick Test-Composite Score; H = hemorrhagic; I = ischemic; NGA = Norwegian Basic Aphasia Assessment; PS = Profile Score of the Aachen Aphasia Test; SS = Speech Scale of the Aachen Aphasia Test; TPO = time post onset, TT = Token Test of the Aachen Aphasia Test; Verbal Exp = verbal expression; WAB AQ = Western Aphasia Battery aphasia quotient.

Table 3. CILT treatment variables and findings

Study	Treatment program/schedule	Outcome type	Outcome measure(s)	Effect size	*p*
Breier et al., 2006	*Treatment*: CILT principles Dual card task with visual barrier Dyad of participants *Schedule*: 3 hr per day 4 days per week for 3 weeks *Total*: 36 hr	I	WAB		
			AQ	0.9 [–1.04, 1.22]	.228
			Repetition	0.00 [–1.13, 1.13]	1.0
			Auditory Comprehension	0.03 [–1.10, 1.17]	.59
		I	BNT	–0.03 [–1.16, 1.10]	.738
		A/P	% CIUs		
			Dual card probes	0.57 [–0.59, 2.25]	.022*
			Accuracy task	1.04 [–0.16, 1.72]	.088
Breier et al., 2007	*Treatment*: CILT principles Dual card task with visual barrier Dyad of participant & clinician *Schedule*: 3 hr per day 4 days per week for 3 weeks *Total*: 36 hr	I	WAB		
			AQ	—	—
			Information Content	—	—
			Fluency	—	—
			Auditory Comprehension	—	—
			Repetition	—	—
			Naming	—	—
		I	BNT	—	—
		I	PALPA		
			Word-Picture Matching	—	—
			Sentence-Picture Matching	—	—
		A/P	% CIUs		

			Dual card task probes	—	—
			Generalization untrained probes	—	—
Breier et al., 2009	*Treatment*: CILT principles Dual card task with visual barrier Dyad of participants *Schedule*: 3 hr per day 4 days per week for 3 weeks *Total*: 36 hr	I	WAB		
			AQ	—	<.004*
		A/P	% CIUs		
			Dual card task ($N = 9$)	1.06 [0.08, 2.05]	<.05*
Faroqi-Shah & Virion, 2009	*Treatment:* CILT principles Dual card task with visual barrier & additional tense morphology shaping Dyad not stated *Schedule*: 3 hr per day for 10 days *Total*: 24 hr	I	WAB + BNT + OAB (language *t* score)	Post: 0.18 [–1.21, 1.57] f/u: 0.38 [–1.01, 1.78]	Post: .075 f/u: .127
		I	WAB AQ	Post: –0.76 [–0.67, 2.2] f/u: –0.09 [–1.48, 1.29	Post: .178 f/u: .498
		I	OAB	Post: 0.29 [–1.10, 1.68] f/u: 0.84 [–0.61, 2.28]	Post: .65 f/u: .353
		I	BNT	Post: –0.21 [1.61, 1.18] f/u: 0.38 [–1.02, 1.77]	Post: .348 f/u: .074
		I	Verb Inflection Test	Post: 0.84 [–0.61, 2.28] f/u: –0.37 [–1.77, 1.03]	Post: .066 f/u: .08
		A/P	Cinderella Narrative & Conv.		
			Proportion Sentences	Post: 0.00 [–1.39, 1.39] f/u: –0.27, –1.66, 1.12]	Post: .9 f/u: .493
			Proportion of Well Formed Sentences	Post: 0.61 [–0.8, 2.03] f/u: –0.11 [–1.49, 1.28]	.059 f/u: .884
			Tense Accuracy	Post: 0.4 [–1.0, 1.8] f/u: –0.05 [–1.44, 1.34]	Post: .364 f/u: .962
			Tense Diversity	Post: 0.75 [–0.44, 2.25] f/u: 0.44 [–0.96, 1.85]	Post: .192 f/u: .444
Goral & Kempler, 2009	*Treatment*: CILT principles Dual card task with visual barrier	I	BDAE	—	—
		A/P	Treatment Block 1		

	Structured tasks with target verbs (e.g., picture description). Unstructured tasks with no target verb (e.g., story construction). 2–3 tasks per session. Dyad of participant & clinician *Schedule*: 5 hr per day for 4 days *Total*: 20 hr per treatment block		Narrative – Total Words	Post: < 1 f/u: –1.96	*ns* —
			Narrative – % of Verbs	Post: 1.97[a] f/u: < –1	— *ns*
		A/P	Treatment Block 2		
			Narrative – Total Words	Post: 8 f/u: < 1	— —
			Narrative – % of Verbs	Post: 2.2 f/u: < –1	— —
		A/P	Social Communication	0.43 [–0.21, 1.05]	.003*
Kirmess & Maher, 2010	*Treatment*: CILT principles Dual card task with visual barrier Dyad of participants *Schedule*: 1.15–3 hr per day for 10 days *Total*: *M* = 24.8 hr	I	NGA		
			Overall	0.34 [–1.23, 2.00]	—
			Naming	0.85 [–0.09, 2.42]	.030*
			Auditory Comprehension	0.03 [–1.58, 1.62]	.789
			Writing	0.32 [–1.35, 1.89]	.547
		I	PALPA Naming Frequency	0.75 [–1.18, 2.06]	.167
		I	VOST Sentence Construction	1.16 [–0.95, 2.34]	.138
		I	TROG-2	0.12 [–1.47, 1.74]	.141
		A/P	CILT		
			Dual card task – high & low frequency requests	0.93 [–1.10, 2.16]	—
Meinzer et al., 2006	*Treatment*: CILT principles Dual card task with visual barrier Dyad not stated *Schedule*: 3 hr per day for 10 days *Total*: 30 hrs	I	AAT		
			Profile Score	—	S
			Token Test – Errors	—	*ns*
			Repeating	—	S
			Written Language	—	*ns*

			Naming	—	*ns*
			Comprehension	—	*ns*
		I	Naming Test		
			Corrected Responses	—	—
			Self-Corrected Responses	—	—
Meinzer et al., 2007	*Treatment*: CILT principles Dual card task with visual barrier 1 participant dyad *Schedule*: 3 hr per day for 10 days *Total*: 30 hr	I	AAT		
			Profile Score	—	S
			Token Test - Errors	—	S
			Naming	—	*ns*
		I	Naming Test	—	—
Meinzer et al., 2008	*Treatment*: CILT principles Dual card task with visual barrier 1 participant dyad *Schedule*: 3 hr per day for 10 days *Total*: 30 hr	I	AAT		
			Profile Score	0.45 [–0.40, 1.30]	<.0001*
			Token Test – Errors	0.31 [–0.53, 1.15]	.003*
			Repeating	0.21 [–0.63, 1.04]	.002*
			Written Language	0.31 [–0.33, 1.15]	.009*
			Naming	0.34 [–0.50, 1.19]	.004*
			Comprehension	0.22 [–0.62, 1.06]	.008*
		I	Naming		
			Trained Items	1.11 [0.21, 2.01]	.0008*
			Untrained Items	0.62 [–0.23, 1.48]	.002*
Meinzer et al., 2009	*Treatment*: CILT principles Dual card task with visual barrier Dyad of participants *Schedule*: 3 hr per day for 10 days *Total*: 30 hr	I	AAT		
			Profile Score	0.34 [–0.55, 1.22]	<.001*
			Written Language	0.23 [–0.65, 1.11]	<.02*
Meinzer, Streiftau,	*Treatment*: CILT principles	I	AAT – SLP		

& Rockstroh, 2007	Dual card task with visual barrier Dyad of participants *Schedule*: 3 hours per day for 10 days *Total*: 30 hr		Profile Score	0.45 [–0.44, 1.33]	<.0001*
			Token Test	0.31 [–0.57, 1.19]	<.008*
			Repeating	0.51 [–0.38, 1.40]	<.004*
			Written Language	0.18 [–0.70, 1.06]	<.036*
			Naming	0.31 [–0.57, 1.20]	<.01*
			Comprehension	0.31 [–0.57, 1.19]	<.009*
		I	AAT – Relatives		
			Profile Score	0.54 [–0.35, 1.44]	<.0002*
			Token Test	0.39 [–0.49, 1.28]	<.0002*
			Repeating	0.53 [–0.36, 1.43]	<.0006*
			Written Language	0.20 [–0.68, 1.08]	<.006*
			Naming	0.46 [–0.43, 1.34]	<.014*
			Comprehension	0.48 [–0.41, 1.36]	<.002*
		I	Relatives vs. SLPs		
			Profile Score	–0.45 [–1.34, 0.44]	>.27
			Token Test	0.15 [–0.73, 1.03]	>.77
			Repeating	–0.84 [–1.75, 0.08]	>.46
			Written Language	0.00 [–1.41, 1.41]	>.17
			Naming	–0.36 [–1.25, 0.52]	>.59
			Comprehension	0.43 [–0.46, 1.32]	>.77
Richter, Miltner, & Straube, 2008	*Treatment*: CILT principles Dual card task with visual barrier Dyad of participants *Schedule*: 3 hr per day for 10 days *Total*: 30 hr	I	AAT		
			Token Test	–0.05 [–0.76, 0.65]	*ns*
			Spontaneous Speech	0.37 [–0.34, 1.08]	<.0001*
		I	ANELT		
			Auditory Comprehensibility	0.28 [–0.42, 0.91]	<.01*

			Semantic Comprehensibility	0.59 [–0.12, 1.29]	<.05*
Szaflarski et al., 2008	*Treatment*: CILT principles Dual card task with visual barrier Dyad of participants *Schedule*: 3 hr per day plus 30–45 min informal socialization breaks for 5 days *Total*: 15 hr		BDAE-3		
		I	Auditory Comprehension	0.27 [–1.34, 1.87]	.328
		I	Verbal Expression	–0.04 [–1.64, 1.56]	.423
		I	Language Communication Index	0.14 [–1.47, 1.74]	.312
		I	Fable Retell – Utterances	0.80 [–1.24, 2.83]	.090
		I	Fable Retell – Words	0.31 [–1.66, 2.28]	.051
		I	Fable Retell – Word Roots	0.99 [–1.09, 3.07]	.186
		I	Fable Retell – MLU	0.02 [–1.94, 1.98]	.947
		I	Fable Retell – TTR	0.16 [–1.8, 2.13]	.618

Note. Dashes indicate data not reported by study author or data not calculable. ANELT = Amsterdam Nijmegen Everyday Language Test; AAT = Aachen Aphasia Test; A/P = activity/participation measure; AQ = aphasia quotient; BDAE-3 = Boston Diagnostic Aphasia Examination–3; BNT = Boston Naming Test; CIUs = content information units; I = impairment measure; MLU = mean length of utterance; NGA = Norwegian Basic Aphasia Assessment; OAB = Object Action Battery; PALPA =Psycholinguistic Assessment of Language Processing in Aphasia; S = significant; TROG-2 = Test for Reception of Grammar–2TTR = type–token ratio; VOST = Verb and Sentence Test; WAB = Western Aphasia Battery.

[a]Effect size change based on Goral & Kempler reported correction.

*Denotes a significant change.

Table 4. Intervention variables and findings for intensity studies.

Study	Treatment program/schedule	Outcome type	Outcome measure(s)	Effect size	*p*
Bakheit et al., 2007	*Treatment:* targeting naming and conversation *Intensive*: 5 hr per week; *M* = 35.6 hr (16.4); total sessions: 37.16 (14.9) *Standard Care*: 2 hr per week; *M* = 19.3 hr (6.4); total sessions: 8.6 (6.4) *Total*: 12 weeks	I	WAB AQ		
			Week 4	0.05 [–0.37, 0.48]	.88
			Week 8	0.09 [–0.37, 0.54]	.98
			Week 12	0.15 [–0.31, 0.61]	*ns*
			Week 24	0.07 [–0.41, 0.56]	*ns*
Harnish et al., 2008	*Treatment*: targeting word finding and phonological processing *Massed*: 1.5 hr per day; 5 days per week for 2 weeks *Distributive*: 1 hr per day; 2 days per week for 7.5 weeks *Total*: 15 hr massed; 15 hr distributive	I	BNT		
			Massed	—	—
			Distributive	—	—
Ramsberger & Marie, 2007	*Treatment*: MossTalk computer naming treatment 45–60 min sessions *Nonintensive*: 2 sessions per week; total: 15 sessions *Intensive*: 5 sessions per week; total: 20 sessions	I	Naming		
			Participant 1		
			Intensive	Post: 5.53 f/u: 3.61	Post: .03* f/u: .26
			Nonintensive	Post: 4.00	Post: <.01*
			Participant 2		
			Intensive	Post: 2.08 f/u: 2.20	Post: .07 f/u: .06
			Nonintensive	Post: 2.44	Post: .09
			Participant 3		
			Intensive	Post: 4.68 f/u: 4.70	Post: <.01* f/u: <.01*
			Nonintensive	Post: 4.98	Post: <.01*
			Participant 4		
			Intensive	Post: 3.79	Post: <.01*

		f/u: 5.74	f/u: .06
	Nonintensive	Post: 4.96	Post: .03*

Note. Dashes indicate not reported by study author or not calculable. A/P = activity/participation; BNT = Boston Naming Test; I = impairment; WAB AQ= Western Aphasia Battery aphasia quotient.
*Denotes a significant change.

Appendix

A1. Clinical questions

Intensity:

1. For stroke-induced chronic aphasia, what is the influence of treatment intensity on measures of language impairment?
2. For stroke-induced chronic aphasia, what is the influence of treatment intensity on measures of communication activity/participation?
3. For stroke-induced acute aphasia, what is the influence of treatment intensity on measures of language impairment?
4. For stroke-induced acute aphasia, what is the influence of treatment intensity on measures of communication activity/participation?
5. For stroke-induced chronic aphasia, what treatment outcomes are maintained following intensive language treatment?

CILT:

6. For stroke-induced chronic aphasia, what is the influence of constraint-induced language therapy on measures of language impairment?
7. For stroke-induced chronic aphasia, what is the influence of constraint-induced language therapy on measures of communication activity/participation?
8. For stroke-induced acute aphasia, what is the influence of constraint-induced language therapy on measures of language impairment?
9. For stroke-induced acute aphasia, what is the influence of constraint-induced language therapy on measures of communication activity/participation?
10. For stroke-induced chronic aphasia, what treatment outcomes are maintained following constraint-induced language therapy?

A2. Search Methodology

Electronic Databases Searched:

PubMed (www.ncbi.nlm.nih.gov/pubmed/)
CINAHL (EBSCO)
Health Source: Nursing (EBSCO)
Psychology and Behavioral Sciences Collection (EBSCO)
PsycINFO (EBSCO)
Communication & Mass Media Complete (EBSCO)
Education Research Complete (EBSCO)
ComDisDome (CSA)
CSA Neurosciences Abstracts
ERIC (CSA)
LLBA (CSA)
CSA Social Services Abstracts
ISI Web of Science
Cochrane Library (Wiley)
ScienceDirect
SUMSearch (http://sumsearch.uthscsa.edu/)
SpeechBITE (www.speechbite.com/)
REHABDATA (www.naric.com/research/rehab/)
TRIP Database (www.tripdatabase.com/)
Latin American and Caribbean Center on Health Sciences Information (LILACS) (www.bireme.br/php/index.php?lang=en)
NHS Evidence Health Information Resources (formerly National Library for Health) (www.library.nhs.uk/)
The Aphasiology Archive (http://aphasiology.pitt.edu/)
HighWire Press (http://highwire.stanford.edu)
GoogleScholar

Search Criteria:

- Date range: 2006 to present
- Peer-reviewed journal (including in-press studies)
- English only
- Must be a study with original data that addresses one or more of the clinical questions
- For clinical questions related to intensity, the keywords *intensity* or *amount of treatment* must be included in the abstract or title and studies must directly compare frequency/intensity of treatment.

Inclusion Criteria**:**

- Adults ages 18 and older
- Individuals with stroke-induced aphasia

Exclusion Criteria:

- Studies with individuals with cognitive deficits
- Studies that include pharmacological intervention
- Individual studies that are included in accepted systematic reviews or meta-analyses

Search Terms:
Constraint Induced Language Treatment OR CILT
Constraint Language Treatment OR CLT
Constraint Induced Aphasia Treatment OR CIAT
Constraint Aphasia Treatment
Forced Language Treatment
Intensive Language-Action Therapy OR ILAT

Aphasia (exploded MeSH term)
Stroke (exploded MeSH term)
Amount OR Intensity OR Frequency OR Duration OR Length of Treatment
Treatment Schedule
Verbal Expression or Speech Output
Adult

Expanded Search Terms:
("Aphasia/rehabilitation"[Mesh] OR "Aphasia/therapy"[Mesh]) AND ("Stroke"[Mesh]) AND ("Treatment Outcome"[Mesh] OR amount OR intense OR intensit* OR frequent OR frequenc* OR duration OR length OR schedule OR session)

("Aphasia/rehabilitation"[Mesh] OR "Aphasia/therapy"[Mesh]) AND ("Language Therapy/methods*"[Mesh])

(constrain* induced aphasia)

(constrain* OR forced OR intensive OR intense OR intensity) AND (language OR aphasia) AND (treatment OR therapy OR program)

"Cerebrovascular disorders"[MeSH Major Topic] AND "aphasia/therapy"[MeSH Major Topic]

"Cerebrovascular disorders"[MeSH Major Topic] AND "aphasia "[MeSH Major Topic] AND (amount OR intens* OR freq* OR duration OR length OR schedule)

"Aphasia/therapy"[MeSH Major Topic] AND stroke

“Aphasia/rehabilitation"[MeSH Major Topic] AND (stroke OR “cerebrovascular disorders"[MeSH Major Topic])

“Aphasia"[MeSH Major Topic] AND stroke AND (amount OR intens* OR freq* OR duration OR length OR schedule)
“Aphasia/rehabilitation"[MeSH Major Topic] OR “aphasia/therapy"[MeSH Major Topic]

(Constrain* OR forced) AND “language therapy”

CILT OR CIAT OR CLT

“Language"[MeSH Major Topic] AND (constrain* OR forced) AND (treatment OR therapy OR rehabilitation OR intens*)

“Aphasia/therapy"[MeSH Major Topic] AND “time factors"[MeSH Major Topic] ("Cerebrovascular disorders"[MeSH Terms] OR "cerebrovascular accident"[MeSH Terms]) AND "rehabilitation of speech and language disorders"[MeSH Terms]

("Cerebrovascular disorders/rehabilitation"[MeSH Terms] OR "cerebrovascular accident/rehabilitation"[MeSH Terms]) AND (speech OR language OR communication OR aphasi*)

("Cerebrovascular disorders/rehabilitation"[MeSH Terms] OR "cerebrovascular accident/rehabilitation"[MeSH Terms]) AND ("language disorders"[MeSH Terms] OR "speech disorders/rehabilitation"[MeSH Terms])

"Aphasia"[MeSH Terms] AND (amount OR intens* OR freq* OR duration OR length OR schedule)

Model orientated aphasia therapy

MH = Major Heading
RH = Rehabilitation
TH = Therapy

(MH "Aphasia/RH/TH") AND (constrain* OR forced OR intensive OR intense OR intensity)

(MH "Aphasia/RH/TH") AND (amount OR intensit* OR frequent OR frequenc* OR duration OR length OR schedule OR session)

(MH "Stroke/RH/TH") AND (aphasi* OR language OR constrain* OR forced OR verbal OR speech) AND (amount OR intensit* OR frequent OR frequenc* OR duration OR length OR schedule OR session)

(Constrain* induced language) OR (constrain* language) OR forced language OR forced language treatment

((MH "Cerebrovascular Disorders+")) AND (MH "Aphasia+/RH/TH")

((MM "Cerebral Vascular Accident") OR (MH "Cerebral Vascular Accident")) AND (MH "Rehabilitation, Speech and Language+")

(MH "Aphasia+/RH/TH") AND (amount OR intens* OR freq* OR duration OR treatment schedule)

((MH "Cerebrovascular Disorders+") OR (MH "Cerebral Vascular Accident")) AND (MH "Language Disorders+") and (MH "Rehabilitation, Speech and Language+")

(MH "Aphasia/RH/TH") AND stroke

(MH "Aphasia+") AND (amount OR intens* OR freq* OR duration OR length OR schedule)

((MH "Cerebrovascular Disorders+") OR (MH "Cerebral Vascular Accident")) AND aphasia

DE= Subject

(DE "APHASIA" AND PT "ACADEMIC JOURNAL") OR (DE "APHASIA --*" AND PT "ACADEMIC JOURNAL")

(constrain* induced aphasia)

(constrain* OR forced OR intensive OR intense OR intensity) AND (language OR aphasia) AND (treatment OR therapy OR program)

(model orientated aphasia therapy) OR (intensive language action therapy)

(constrain* OR forced OR intensive OR intense OR intensity) AND aphasia treatment

DE = Thesaurus term

(DE "Aphasia" OR DE "Acalculia" OR DE "Agnosia" OR DE "Agraphia" OR DE "Dysphasia")AND (language OR constrain* OR forced OR verbal OR speech) AND (amount OR intensit* OR frequent OR frequenc* OR duration OR length OR schedule OR session)

(DE "APHASIA" OR DE "AGRAMMATISM" OR DE "ANOMIA" OR DE "CONDUCTION aphasia" OR DE "JARGON aphasia" OR DE "WORD deafness") AND (language OR constrain* OR forced OR verbal OR speech) AND (amount OR intensit* OR frequent OR frequenc* OR duration OR length OR schedule OR session)

((Aphasia AND stroke) OR (aphasia AND (amount OR intens* OR freq* OR duration OR length OR schedule)) OR (constrain* AND (language OR aphasia))) AND DE "APHASIA"

“treatment of aphasia” exploded

DE=descriptor

DE=("aphasia 03400") AND DE=("language therapy 44400")
DE="language therapy" and DE="stroke rehabilitation"

Q1=article subject terms

Q1="language" and Q1="aphasia" AND (constrain* OR forced OR amount OR intensive OR intensit* OR frequent OR frequenc* OR duration OR length OR schedule OR session)

DE=descriptor

DE="aphasia" and DE="outcomes of treatment" and DE="therapy"

(DE "Aphasia") AND stroke

(DE "Aphasia") AND (amount OR intens* OR freq* OR duration OR length OR schedule)

(Stroke) AND (DE "Time Factors (Learning)")

(DE "Aphasia") AND (DE "Time Factors (Learning)")

(Stroke) AND (amount OR intens* OR freq* OR duration OR length OR schedule)

(Stroke) AND (DE “Communication Disorders”)

(DE “Communication Disorders”) AND ((DE "Time Factors (Learning)") OR (amount OR intens* OR freq* OR duration OR length OR schedule))

(Constrain* induced language/aphasia) OR (constrain * language/aphasia) OR forced language/aphasia

DE="aphasia 03400" and DE="language therapy 44400"

DE=("aphasia" AND "language therapy") AND (stroke OR (amount OR intens* OR freq* OR duration OR length OR schedule))

DE="language therapy" AND (amount OR intens* OR freq* OR duration OR length OR schedule) AND stroke

DE=("aphasia" AND "language therapy") AND (speak* OR speech OR spoken OR verbal OR express*)

DE=(“aphasia”) AND (treatment OR therapy OR rehabilitation) and (amount OR intens* OR freq* OR duration OR length OR schedule)

(DE="language therapy" OR "speech therapy") AND (speak* OR speech OR spoken OR verbal OR express*) AND (amount OR intens* OR freq* OR duration OR length OR schedule)

(constrain* induced aphasia) OR (intensive language action therapy)

(constrain* OR forced OR intensive OR intense OR intensity) AND (language OR aphasia) AND (treatment OR therapy OR program)

(constrain* OR forced OR intensive OR intense OR intensity) AND (aphasia treatment)

(constrain* OR forced) AND (language therapy)
("Aphasia/rehabilitation"[Mesh] OR "Aphasia/therapy"[Mesh]) AND ("Stroke"[Mesh]) AND ("Treatment Outcome"[Mesh] OR amount OR intense OR intensit* OR frequent OR frequenc* OR duration OR length OR schedule OR session)

("Aphasia/rehabilitation"[Mesh] OR "Aphasia/therapy"[Mesh]) AND ("Language Therapy/methods*"[Mesh])

Anywhere in Text: constraint induced language

Anywhere in Text: constraint induced aphasia

Anywhere in Text: constraint constrained forced intensive intense intensity
Title & Abstract only: language aphasia

Title & Abstract only: intensive language action therapy

Anywhere in Text: constraint constrained forced intensive intense intensity
Title & Abstract only: language therapy

Target area: aphasia
Intervention: language therapy
Client sub-groups: stroke/CVA
Age group: adults

Intensive language
Age group: adults

Keyword(s): forced :: Target area: Aphasia

Keyword(s): intensity :: Target area: Aphasia

aphasia [Abstract words] and constraint [Abstract words]

aphasia [Abstract words] and constrained [Abstract words]

aphasia [Abstract words] and forced [Abstract words]

aphasia [Abstract words] and intensity [Abstract words] and treatment [Abstract words]
aphasia [Abstract words] and intense [Abstract words] and treatment [Abstract words]

aphasia [Abstract words] and intensive [Abstract words] and treatment [Abstract words]

language [Abstract words] and intensity [Abstract words] and treatment [Abstract words]

language [Abstract words] and intense [Abstract words] and treatment [Abstract words]

language [Abstract words] and intensive [Abstract words] and treatment [Abstract words]

ciat [Abstract words] or cilt [Abstract words] or clt [Abstract words]

"constraint induced aphasia"

"constraint induced language"

aphasia AND intens* AND (treatment OR therapy)

Additional Searches:

- The reference lists of all relevant articles identified were scanned for other possible studies.
- All accepted articles were forward-searched on ISI Web of Science.
- All ASHA journals were searched through the HighWire Press website.
- Contemporary Issues in Communication Science and Disorders (CICSD) was hand searched.

The literature search was conducted from March to June 2010 by Beverly Wang. References were managed using the bibliographic software EndNote.

A3. Bibliography of excluded studies

Reason for exclusion: could not separate data from mixed treatments or mixed populations

1. Breier, J. I., Randle, S., Maher, L. M., & Papanicolaou, A. C. (2010). Changes in maps of language activity activation following melodic intonation therapy using magnetoencephalography: Two case studies. *Journal of Clinical and Experimental Neuropsychology, 32*(3), 309–314. Advance online publication. doi: 10.1080/13803390903029293
2. Kavanagh, D. O., Lynam, C., Duerk, T., Casey, M., & Eustace, P. W. (2010). Variations in the presentation of aphasia in patients with closed head injuries. *Case Reports in Medicine,* 5.
3. Martin, P. I., Naeser, M. A., Ho, M., Treglia, E., Kaplan, E., Baker, E. H., & Pascual-Leone, A. (2009). Research with transcranial magnetic stimulation in the treatment of aphasia. *Current Neurology and Neuroscience Reports, 9*, 451–458.
4. Seniów, J., Litwin, M., Litwin, T., Leśniak, M., & Członkowska, A. (2009). New approach to the rehabilitation of post-stroke focal cognitive syndrome: Effect of levodopa combined with speech and language therapy on functional recovery from aphasia. *Journal of the Neurological Sciences, 283*(1–2), 214–218.

Reason for exclusion: pharmacological treatment

5. Berthier, M. L., Green, C., Lara, J. P., Higueras, C., Barbancho, M. A., Dávila, G., & Pulvermüller, F. (2009). Memantine and constraint-induced aphasia therapy in chronic poststroke aphasia. *Annals of Neurology, 65,* 577–585.

Reason for exclusion: did not address clinical question

6. Abel, S., Willmes, K., & Huber, W. (2007). Model-oriented naming therapy: Testing predictions of a connectionist model. *Aphasiology, 21*, 411–447.
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11. Beeke, S., Maxim, J., & Wilkinson, R. (2007). Using conversation analysis to assess and treat people with aphasia. *Seminars in Speech and Language, 28*(2), 136–147.
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13. Burns, M. S. (2008). Application of neuroscience to technology in stroke rehabilitation. *Topics in Stroke Rehabilitation, 15*, 570–579.
14. Carter, A. R., Connor, L. T., & Dromerick, A. W. (2010). Rehabilitation after stroke: Current state of the science. *Current Neurology and Neuroscience Reports, 10*(3), 158–166.
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16. Cherney, L. R. (2010). Oral reading for language in aphasia: Impact of aphasia severity on cross-modal outcomes in chronic nonfluent aphasia. *Seminars in Speech and Language, 31*(1), 42–51.
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